Micronesica 23(1): 27–40, 1990

Periphyton, Excluding Diatoms and Desmids, from Yap, Caroline Islands

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Abstract—Freshwater habitats of Yap, Federated States of Micronesia, are described, including first algal records. Periphyton and other visible algae were collected chiefly from streams and ponds. Streams were well shaded and lacked algae except in clearings; dominant algae were *Schizothrix calcicola* and *Microcoleus* spp. (Cyanophyta) and *Cladophora* sp. (Chlorophyta). Open ponds were dominated by blue-green algal mats, but some also had abundant *Nitella* and desmids. Desmids and diatoms were numerous and will be treated in other papers. The species list is short: 12 blue-green algae, 2 red algae, 2 charophytes, 7 filamentous greens, and 5 flagellates. All are new records for Yap and many for Micronesia. No endemic species were found. The freshwater algal flora of the Yap Islands does not show characteristics of the biota of "oceanic" islands.

Introduction

While there has been considerable study of marine algae in Micronesia (Tsuda & Wray 1977, Tsuda 1978, 1981), freshwater algae have been all but ignored throughout Micronesia, Melanesia, and Polynesia. However, studies of island freshwater algae could contribute to understanding of both tropical limnology and island biology.

The distinctiveness of tropical limnology has recently been emphasized by Lewis (1987), who showed that limnological principles derived from studies of temperate lakes cannot be intuitively extrapolated to tropical lakes. The same is also true for transfer of knowledge of streams and ponds. Most tropical limnology has been carried out in large continental lakes and rivers (see references in Blum 1956, Whitton 1975, Payne 1986, and Lewis 1987), or on off-shore land masses such as in Lake Lanao, Mindanao I., the Philippines (Lewis 1978). Biologists interested in islands (defined as less than 10,000 km^2, see Mueller-Dombois 1980) have studied archipelagoes such as Hawaii and the Galápagos Islands (Williamson 1981; Carlquist 1974). Micronesian islands are tiny compared to the 10,000 km^2 limit: Guam, the largest, is only 540 km^2, and the Yap Islands total only 100 km^2 (cf. Oahu, Hawaii = 1,580 km^2) (Douglas 1969). Biogeographic study in the Indo-West Pacific, such as has been done for the marine fauna (Ekman 1953, Springer 1982) has not yet been attempted with freshwater organisms, though it should provide interesting insights into aerial dispersal as opposed to oceanic drift. Carlquist (1974) does

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note dispersal of algae as aeroplankton and attached to water birds, citing works of Proctor (1966), Brown (1971), and others.

Many islands in Oceania are atolls and have virtually no freshwater bodies; nevertheless, freshwater algae can be found and have been recorded there, e.g. in wells and taro paddies (Moul 1953, May 1966, Maguire 1967). The larger, high islands in Micronesia, such as Palau, Guam, Pohnpei, and Yap, have streams and ponds, and Guam has a small, man-made lake. The records of algae from these waters are few (see bibliographies by Sachet & Fosberg 1955, 1971, Best & Davidson 1981). Even in Hawaii there have been few studies (MacCaughey 1918a, b, Hustedt 1942, Carson & Brown 1978, Fungladda *et al.* 1983, McMillan & Rushforth 1987). Reference to Micronesian freshwater algal collections can be found in Groves (1921) (Chlorophyta), Zanefeld (1940) and Corillion (1958) (Charophyta), Drouet & Daily (1956) and Drouet (1968, 1973, 1978) (Cyanophyta). Freshwater red algae of Truk, Guam, and Palau were thoroughly studied by Bowden-Kerby (1985), who found several new, endemic species (Kumano & Bowden-Kerby 1986); Seto (1979) studied *Thorea* from Guam. Surveys of Guam rivers have included enumeration of algae (Kami *et al.*, unpubl. ms. cited by Best & Davidson 1981) and diatoms (Zolan 1981). There are apparently no records of freshwater algae from Yap.

In the present study freshwater algae were collected in Yap for two weeks during September 1988 as part of an aquaculture assessment survey (Nelson 1989). This report consists of a description of the study areas, together with lists of algae which were identified by F. K. Daily (charophytes), W. A. Daily (cyanophytes), and R. W. Hoshaw (filamentous green algae and euglenoids). Desmids and diatoms were sufficiently numerous, and interesting in their own rights, to warrant separate accounts. A report, with J. F. Gerrath, on desmids is in preparation, and work with J. N. Navarro on diatoms is still in progress.

Yap and its Freshwater Habitats

The Yap Islands consist of a close group of four islands, Yap, Maap, Gagil-Tamil, and Rumung, that lie on the Philippine Plate at about 9°33′ N latitude, 138°08′ W longitude (Fig. 1), some 2400 km east of the Philippines. Yap is geographically part of the Western Caroline Islands, politically part of the Federated States of Micronesia. Peaks on Yap I. reach 180 m but the other islands are below 100 m. Average annual precipitation is 3.1 m. A season of tradewinds and drought extends from December through April. There is a wet season between July and October that accounts for about half the annual rainfall. Typhoons are especially prevalent in the transition months, May–June and November. Although droughts can be severe, rainfall is sporadic (Blumenstock 1960). Average air temperature is 29 C, varying more diurnally than seasonally.

The islands are mainly of metamorphic rock—basement rocks of the West Caroline ridge, in contrast to most Micronesian islands, which are composed of volcanic rock and raised reef limestone. Yap and Rumung are chiefly composed of basement rock—greenschist and amphibolite (Yap formation). In Maap and Gagil-Tamil these are overlain by mixtures of breccias and conglomerates (Map formation) with andesitic and basaltic breccias (Tomil formation) (Johnson *et al.* 1960).

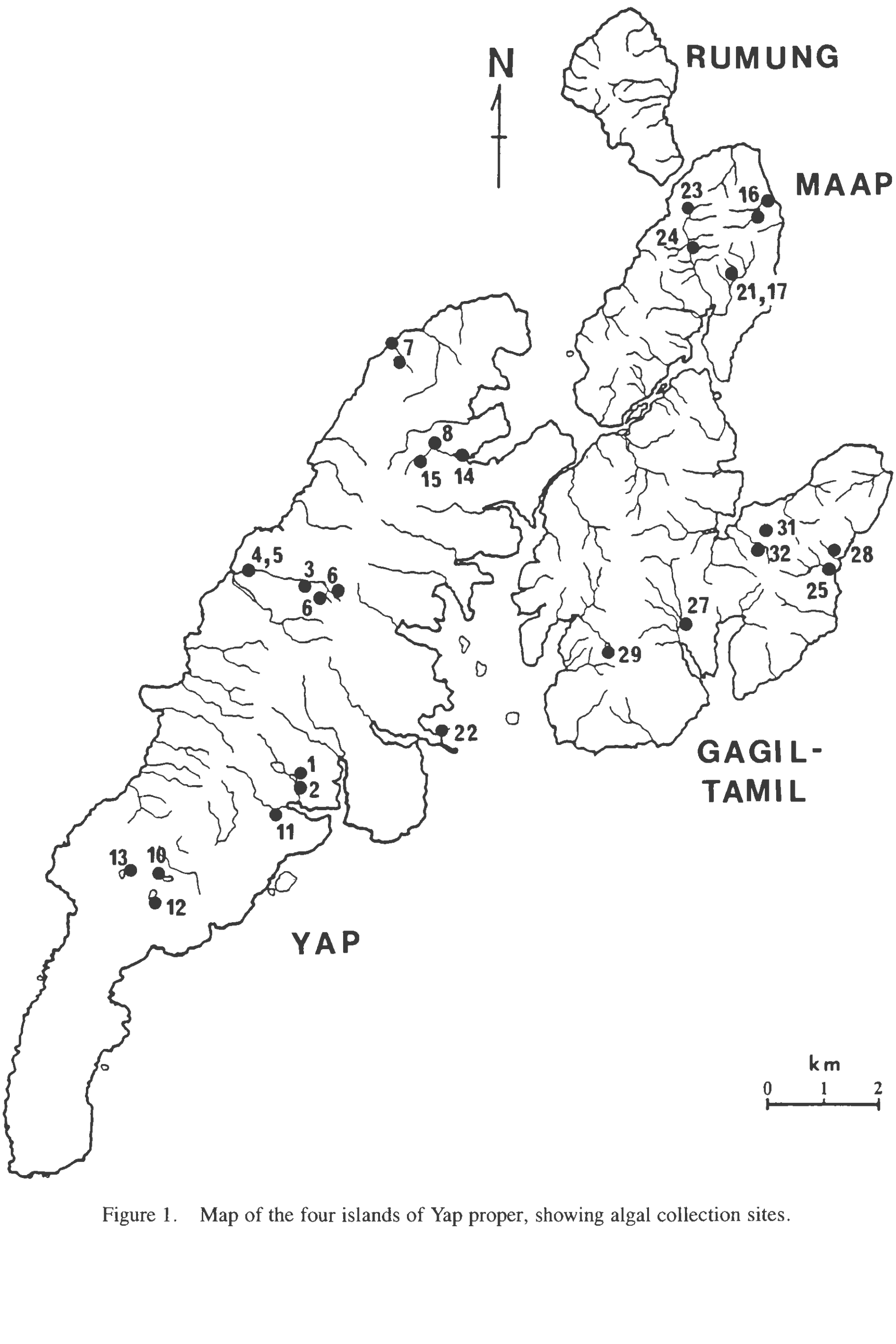

Figure 1. Map of the four islands of Yap proper, showing algal collection sites.

The terrestrial vegetation consists of dense forest, with thick agroforest around the many small villages, and open savannah of grasses [chiefly *Dichanthium bladhii* (Retz.) Clayton], ferns [chiefly *Gleichenia linearis* var. *ferruginea* (Bl.) Rac.], and isolated *Pandanus* spp. trees (Johnson *et al.* 1960). The shore is bordered by mangrove forests in many areas.

Freshwater bodies that were sampled included streams, ponds, a reservoir, cultivated taro paddies [*Cyrtosperma chamissonis* (Schott) Merrill], and puddles. The streams are short and only first or second order (Fig. 1) and most are intermittent. Of the ponds, only "the one at the old airfield" [presumably Machbaab] never dries up (Johnson *et al.* 1960, p. 26), and even the reservoir had dried up during the severe dry season of 1988, just a few months prior to our survey. During heavy runoff, streams are loaded with sediment and scour the algae, but during lower stages they are clear. All streams are heavily shaded by natural forest or agroforest, except at road cuts and other occasional clearings. The stream beds consisted of gravel, silt, leaves, root mats of streamside trees (especially *Hibiscus tiliaceus* L.), and bare rock (in cascades). Patches of muraina grass [*Ischaemum polystachum* var. *intermedium* (Brongn.) Fosb. & Sachet] dominated the streams in some clearings, and moss was common in cascades, but rooted vegetation, like periphyton, was very restricted. As with many forest streams in temperate regions, most organic input is allochthanous (see Moss 1980).

In contrast, the ponds we studied were in open savannah areas and well-lit. They supported considerable rooted vegetation, including emergent species such as *Eleocharis ochrostachys* Steud. (Cyperaceae), *Eriocaulon sexangulare* var. *micronesicum* Mold (Eriocaulaceae), and *Ischaemum,* and the submerged species *Blyxa* sp. (not flowering, but probably *B. aubertii* L. C. Rich.).

Water temperatures during the study period ranged from 26.5–27.5 C in streams, 30–38 C in ponds (Sanger & Hopper 1989). Ammonium, iron, and silicate levels were high (means respectively 4.05 μM, 6.30 μM and 61.18 μM), nitrate and reactive phosphate low (means 0.36 μM and 0.37 μM); mean pH was 7.26 (Sanger & Hopper 1989). These pH and nutrient levels are comparable to data on other tropical streams (Bright 1979, Lewis 1986, Payne 1986, Yavitt & Weider 1988).

Materials and Methods

Sampling was carried out September 15–27, 1988 and covered three of the four Yap Islands: Yap, Maap, and Gagil-Tamil. The primary work of the expedition was a pre-aquaculture survey of vertebrates and macroinvertebrates (Nelson 1989). Streams and ponds were selected in as many parts of the islands as possible, and second-order streams were included as much as possible. In general, algal samples were collected (by C. S. L. and M. S.) at the zoological study sites or within about 100 m up and downstream, depending on access. A few streams, e.g. Qokkaw, Malawaay, Yyin, and Wanead, were surveyed over 500 m starting in the estuaries. More than 150 algal samples were collected, which represents one of the most extensive samplings of any Pacific island.

Visible algae (as well as rooted aquatic angiosperms) were collected by hand from rocks, sediments, and rooted vegetation. "Visible algae" included periphyton (communities attached to substrates, as defined by Wetzel 1983), floating algal mats, and occasional dense aggregates of phytoplankton. Some planktonic algae were found trapped in algal mats, but no plankton tows were made. Collections were examined each day before preserving in ca. 5% formaldehyde or pressing onto herbarium paper. Specimens were later subdivided and portions sent to the taxonomic experts (F. K. D., W. A. D. and R. W. H.) for identifications. Voucher specimens are maintained at the Marine Laboratory of the University of Guam, and in most cases the experts retained portions for their herbaria.

Collecting Sites

Spellings and coordinates of collecting sites are taken from the *U.S. Geological Survey Topographic Map of Yap (Wa'ab).* Station numbers not listed were either exclusively marine or yielded no visible algae.

Yap

Y1. Gitaem: water treatment plant impoundment (82.5 × 52.2). Root tufts of *Ipomoea aquatica* were sampled for periphyton. 15 Sep. 88.

Y2. Gitaem: reservoir outfall stream (82.5 × 52.1), especially the face of the dam. Abundant *Ischaemum* along top of dam; moss and filamentous greens dominating the dam face. 15 Sep.

Y3. Qokaaw: second-order stream near the village (close to mouth where it empties into mangal) (82.5 × 55.9). Riffles with pebbly bed; silty pools; *Ischaemum* patch. Also collected in adjacent flooded taro paddies (including green filaments on floating coconut husks), in a cultivated taro and kangkong (chinese spinach) paddy, and in a roadside puddle. 16–17 Sep.

Y6. Qokaaw: upper part of stream, near Tabilaeg, on primary tributary (83.1 × 55.3). 17 Sep.

Y7. Yyin: estuary (no mangal) and lower part of freshwater stream (84.1 × 60.2 to 84.2 × 60.1). Series of rock scrapings and sediment samples collected from fully marine (stream empties onto reef flat facing open ocean) up into freshwater stream. (Only freshwater samples from reported here.) Stream bed chiefly root mat in riffles, leaf litter in pools; no visible algae. 18 Sep.

Y8. Malawaay: stream above village (85.0 × 58.3). Study site included a clearing with range of sun and shade habitats, *Ischaemum* patch and pebbly bed. *Batrachospermum* and many other algae here. See also Y14, Y15. 18 Sep.

Y10. Luweech: deep pond by old airport (80.1 × 50.4). Floating grass mat at edge; periphyton on stems was sampled. 19 Sep.

Y11. Gitaem: south stream near junction of road to High School (82.3 × 51.7); algae especially on concrete culvert ramp under main road, where well lit. A stromatolite was noted in a seep further upstream. 19 Sep.

Y12. Luweech: pond at weather station (80.0 × 50.0). Shallow (< 1m deep); thick benthic algal mat in pond and also on exposed soil at edge of pond. Some *Nitella* in pond. 20 Sep.

Y13. Machbaab Pond (79.5 × 50.4), not far from Y12. Another shallow pond with very dense benthic algal mat and floating algal benthos. *Blyxa* and *Nitella* abundant. 20 Sep.

Y14. Malawaay: estuary (no mangal) and lower part of stream (85.2 × 58.2). (Similar series of samples to Y7; Malawaay at head of protected inlet). 21 Sep.

Y15. Malawaay: stream above Y8 (84.8 × 58.2). 21 Sep.

Y22. Colonia: water-filled post hole and larger hole at edge of concrete dock at Marine Resources Management Division (84.8 × 53.1). 22–23 Sep.

Maap

Y16. Wanead (91.0 × 62.9): Estuarine series from reef flat to full freshwater, as Y7. Stream had a few well-lit areas with blue-green and green mats. Also sampled a roadside puddle. 22 Sep.

Y17. Wachaelaeb: stream at road to Choqol (90.4 × 61.7). 22 Sep.

Y21. Puddle in roadside ditch ca. 50 m south of Y17. 22 Sep.

Y23. Qamin: headwaters of large stream system: two first-order branches just above confluence (89.4 × 62.7). Isolated patches of algae but most riffles and runs and all pools without visible algae. 23 Sep.

Y24. Siminmin: second order tributary of same system (89.3 × 62.2). Culvert under road but shady, in contrast to Y11, Y17. 23 Sep.

Gagil-Tamil

Y25. Wanyaan: stream near St. Joseph's Church (92.1 × 56.2). Estuarine series. *Thorea* population in lower fully freshwater reaches. Also sampled dense concentration of euglenoids in a taro paddy, and green filaments in a puddle. 24 Sep.

Y27. Thool: stream, and also flowing drainage channel along edge of a taro paddy (89.4 × 55.2); both with *Nitella*. 26 Sep.

Y28. Wanyaan: very small stream to the north of Y25 (92.2 × 56.4). 26 Sep.

Y29. Toqayong Pond (88.1 × 54.8). Shallow pond comparable to those on Yap. Very muddy at time of visit because of heavy rains. Abundant algal mat and also collected jelly colonies with blue-greens and rich in desmids. 26 Sep.

Y31. Qamun: well-lit taro paddy with floating green filaments (90.8 × 56.9). 27 Sep.

Y32. Qamun: stream (90.7 × 56.7). 27 Sep.

Guam

Samples used for comparison (all Fena Lake watershed, Oct. 8/88):

G1. Maulup River.

G2. Fena Lake. While still a small lake, Fena is much bigger and deeper than the ponds in Yap, and has substantial water flow-through.

G3. Imong River.

G4. Alamagosa River.

All streams were second-order at points sampled, and much larger than Yap streams, generally >1 m wide, better lit, and with abundant green filaments on rocks and trailing vegetation. Pond weed [*Hydrilla verticillata* (L.f.) Royle] was common, especially in the

Maulup, again in contrast to Yap streams. Samples from these collections were sent out with the Yap samples.

Results

The freshwaters of Yap are characterised by very patchy distribution of algae in generally shady and barren streams, but a rich pond flora. Where algae were present, blue-green algae appeared to be most abundant, with diatoms and green algae also common. The habitats are discussed below, and a species distribution list is given in Table 1.

Streams

On stable substrates such as pebbles, rocks, concrete culvert ramps, firm mud banks, and rooted plants, algae were seen growing, provided the trees were not too dense. There were some common species that were encountered in several streams, but no alga was consistently present in well-lit, stable habitats.

Filamentous blue-green algae in the family Oscillatoriaceae, especially *Schizothrix calcicola,* were the most common algae, not only in streams but also in ponds and other standing water such as puddles and taro swamps. These algae also tended to be very abundant when present, forming thick gelatinous mats that appeared blue-green, green, brown, or black. One stream habitat dominated by blue-greens was concrete culvert ramps. In other places, blue-greens were often replaced by or mixed with filamentous green algae. Several species of greens were found in streams, the most common being a species of *Cladophora,* which forms short, stiff, dark green tufts in riffles and runs. Among the green algal filaments and in the blue-green algae mats, were many diatoms.

Two exceptional populations of red algae were found on pebbles in different streams. In the upper reaches of the stream at Malawaay, a population of a *Batrachospermum* sp. occurred along with blue-greens and *Cladophora.* In the lower part of the stream at Wanyaan, and not far above the tidal reach, a large, pure stand of *Thorea* was found. Salinity was checked with a refractometer at both low and high tide and was always 0.0. These red algae were not fertile and the alternate, "Chantransia" stages were not found.

Ponds and other lentic habitats

Large algal populations were found, overwhelmingly blue-green algae, which formed mats on the bottom and floating on the surface. The bottom mat sometimes extended onto the damp shore. Also present in two ponds was the charophyte *Nitella pseudoflabellata.* Desmids were common and diatoms scarce in ponds.

The puddles from which collections were made ranged from some 9 m^2 to a mere post-hole. Blue-green algae, including a form of *Microcoleus vaginatus* with distinctive short filaments bundled into a common sheath, again tended to be common. *Spirogyra* sp. occurred in two of the largest puddles.

The standing water in taro paddies ranged from puddles to complete flooding. In fully-flooded paddies the duckweed, *Lemna perpusilla* Torrey sometimes completely covered the water surface. In others phytoplankton aggregates (*Euglena* sp.) were sometimes seen in sunspots. Several taro paddies had flowing water but little algal growth. However, an unusual paddy at Thool had a species of *Nitella* different from that in the ponds, which

Table 1. Species of algae, excluding desmids and diatoms, collected from freshwaters in Yap and Guam. Station numbers are identified in Collecting Sites.

Taxon	Streams	Ponds	Paddies, etc.
CYANOPHYCEAE			
Chroococcales			
Chroococcaceae			
Anacystis marina (Hansg.) Dr. & Daily		Y13	
Chamaesiphonaceae			
Entophysalis Lemaniae (Ag.) Dr. & Daily			Y3
Hormogonales			
Oscillatoriaceae			
Schizothrix calcicola (Ag.) Gom.	Y2, Y3, Y11, Y17, G1	Y10, Y12, Y29, G2	Y3
Microcoleus vaginatus (Vauch.) Gom.	Y8, Y32	Y13, G2	Y3
M. lyngbyaceus (Kütz.) Crouan	Y8, Y11, Y24, G3		Y22
Oscillatoria princeps Vauch.			Y3, Y22
O. lutea Ag.	Y14, Y15		
O. retzii Ag.	Y16		
O. submembranacea Ard. & Straff.		G2	
Nostocaceae			
Calothrix parietina (Näg.) Thur.	Y8	Y12, G2	
Nostoc commune Vauch.		Y13	
Scytonema Hoffmanni Ag.	Y17		Y22
Stigonemataceae			
Stigonema muscicola (Thur.) Borzi		Y12	
RHODOPHYCEAE			
Batrachospermales			
Batrachospermaceae			
Batrachospermum sp.	Y8		
Thoreaceae			
Thorea sp.	Y25		
EUGLENOPHYCEAE			
Euglenales			
Euglenaceae			
Euglena sp.	Y24, G3		Y3, Y6, Y31
Phacus sp.	G3		Y6, Y31
Trachelomonas sp.			Y6

was also present in the adjacent stream. A taro/kangkong marsh in Qokaaw had a particularly rich and diverse algal flora, including blue-green and green filaments and various euglenoids, dinoflagellates, and other plankton.

Guam

Stream samples from Guam were dominated by *Spirogyra* sp(p)., with *Oedogonium* sp. commonly intermixed. In other Guam streams *Spirogyra* is also the dominant green, even in more forested sections, and *Cladophora* sp. occurs only rarely (Lobban, unpubl. observations). Blue-green algae were much less common than in Yap but still formed significant periphyton communities in some areas, and were the main constituent of floating

Table 1.
(*continued*)

Taxon	Streams	Ponds	Paddies, etc.
DINOPHYCEAE			
Peridiniales			
Peridiniaceae			
Peridinium elpatiewskyi (Osten.) Lemm.		Y12, G2	
CHLOROPHYCEAE			
Chlorococcales			
Scenedesmaceae			
Scenedesmus sp.	Y2, Y24	Y1	
Cladophorales			
Cladophoraceae			
Cladophora sp.	Y3, Y15, Y23, Y24, Y25, Y32 Y32, G1, G4		Y6
Rhizoclonium sp.	Y2, Y7, Y14, Y15, Y24, Y25, Y32		Y3, Y16
Chaetophorales			
Chaetophoraceae			
Chaetophora sp.	Y14		
Oedogoniales			
Oedogoniaceae			
Oedogonium sp.	Y2, Y24, G3, G4		Y6, Y31
Volvocales			
Volvocaceae			
Pandorina sp.	Y25?, G4?		Y6
Zygnematales			
Zygnemataceae			
Spirogyra sp.	G1		Y21, Y22
Mougeotia sp.	Y2		
CHAROPHYCEAE			
Charales			
Nitellaceae			
Nitella pseudoflabellata var. *imperialis* near f. *Wattii* (J. Groves) R. D. Wood		Y12, Y13	
Nitella sp. (*mucronata* group)	Y27		

benthos in Fena Lake. As in Yap, dominant species were *Schizothrix calcicola* and *Microcoleus* spp.

Discussion

Notes on the algae

The predominance of *Spirogyra* sp. in Guam and its scarcity in Yap may be related to irradiance. *Spirogyra* is characteristic of well-lit locations both in the tropics (Bishop

1973) and in temperate streams (Whitford & Schumacher 1963). (The difference in irradiance is visually striking; however, we did not have a meter to measure light levels.)

Cladophora sp. and *Rhizoclonium* sp. are more common in Yap, although *Cladophora* is always very small (usually only about 10 mm). *Cladophora* also requires high irradiance for luxuriant growth (see Whitton 1975, Fig. 3.1a), but it can tolerate shade. Most populations in Yap were heavily grazed by snails [especially *Neritina variegata* (Lesson)—Smith 1989] and had short cells. One population in Qokaaw stream had very long cells and snails were relatively scarce, but we could not determine if there was any effect of grazing on cell length.

The single dinoflagellate documented, *Peridinium elpatiewskyi,* is significant because the abundance of dead shells from both a Yap pond (Y12) and Fena Lake, Guam, indicates that blooms had taken place earlier in the season. This is the first record of a dinoflagellate in Micronesia. This species is known from Europe and eastern Asia, including Malaysia. Several other species were present but have not been identified.

The location of the *Thorea* population is noteworthy because Bowden-Kerby (1985) found that most Micronesian red algal populations occur in headwaters and springs. The single population of *Thorea* in the Yap Islands, however, was very near the estuary at Wanyaan. Bowden-Kerby (1985) recorded two species of *Thorea;* the specimens from Yap were sterile but may be *T. gaudichaudii* C. Ag., a species first described from Guam (see Seto 1979). John *et al.* (1989) have commented on the patchiness and transience of *Thorea* in the United Kingdom, where it apparently persists largely in the cryptic "Chantransia" stage. Further search for this stage needs to be made in Yap.

Batrachospermum is restricted to shady habitats (Whitford & Schumacher 1963), although shade preference differs among species (Rider & Wagner 1972, Parker *et al.* 1973). Bowden-Kerby found six new species on three islands, and four species occurred on only one island each (Kumano & Bowden-Kerby 1986).

All Micronesian records of Charophytes to date (e.g. Zanefeld 1940, Corillion 1958), and all specimens in the U. Guam herbarium, are species of *Chara,* whereas all collections from Yap were *Nitella,* a genus apparently not previously recorded from the region.

Island biology

Yap's freshwaters revealed a small number of taxa: 28, excluding diatoms and desmids. These comprised 12 blue-green algae, 2 red algae, 7 genera of green algae, 2 charophytes, and 5 sundry flagellates. The list of filamentous green algae could undoubtedly have been increased had species identifications been possible. Chloroplast structure, as seen in fresh material, and reproductive structures are essential criteria that could not be seen in the preserved material. Also in genera such as *Spirogyra,* which exhibits frequent ploidal change (Hoshaw & McCourt 1988), identification is fraught with difficulty, making a listing of characters more accurate than the naming of a species. The flagellates were collected incidentally, when they formed visible aggregations (*Euglena*) or were present in algal mats. Periphyton communities show succession and can undergo abrupt temporal changes (Blum 1956, Whitford & Schumacher 1963), and there can be great spatial heterogeneity due to factors such as light, substratum, and current (Parker *et al.* 1973, Tett *et* *al.* 1978, Cox 1988). Thus more detailed and repeated sampling can be expected to yield more species.

Evaluation of the flora as an island flora can only be tentative, given the limited sampling that was done. However, the number of taxa in the Yap Islands is evidently low in comparison with mainland floras (Whitford & Schumacher 1963, Bishop 1973, Hambrook & Sheath 1988). Carlquist (1974, p. 15) stated bluntly that "biotic depauperation is the criterion for [defining the biogeographic province of] Micronesia."

The reduced flora of Yap may be due to several factors, including the very small size and the isolation of the island group, and the short and ephemeral nature of the streams. Reduction of algal diversity and biomass by shade is typical of small, forested streams (Blum 1956, Whitford & Schumacher 1963, Hynes 1970, Sand-Jensen *et al.* 1988). Better evaluation of the island effect might be gained by studying selected identifiable groups in Yap and other Micronesian islands, as well as in Hawaii, rather than attempting to enumerate entire floras.

Are the Yap Islands oceanic? An oceanic island has many endemic species because evolution is faster than immigration; on a continental island immigration is faster (Williamson 1981). Williamson suggested that, because of different dispersal abilities of organisms, an island might be oceanic for some groups and continental for others. There is no evidence for endemic species among the algae discussed here and all the desmids collected were also known from other, often remote, places (Gerrath & Lobban, in prep.). Although the Yap Islands are remote from large land masses, they are part of a scattered group of islands that could allow "island hopping" both north-south and west-to-east. Algae or their spores (etc.) are small; they can survive dry in dust and are thought to live in water droplets in clouds (Parker 1970). Apparently the freshwater algal flora of the Yap Islands must be regarded as continental, impoverished largely because of the small size of the island group and the nature of the freshwaters.

Acknowledgements

These algal collections were made possible because of an exploratory project on aquaculture potential led by Dr. Stephen G. Nelson, funded by College of Micronesia's land grant program under the U.S. Dept. Agriculture, and carried out in co-operation with Yap State Marine Resource Management Division. C. S. L. and M. S. thank Dr. Nelson for inviting us to join the team. He also provided advice on manuscripts. The field work was very much a team effort, involving both UOG personnel and staff of MRMD, and we thank especially Dave Hopper, Herling Sanger, and Paul Paatmag. Finally, thanks to Lynn Raulerson, UOG, for identifying the vascular vegetation, and F. J. R. (Max) Taylor, University of British Columbia, for identifying the dinoflagellate.

This paper is Contribution No. 283 from The Marine Laboratory, University of Guam.

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NOTE ADDED IN PROOF

Since this paper went to press, Dr. Gerrath has uncovered a paper by W. Schmidle, 1901, in Hedwigia 40: 343–349, containing a description of a few algal samples collected in Yap by Dr. Volkens in spring 1900. The collecting sites are not listed but evidently included a pond, since the records are primarily desmids and *Nitella gracilis* (Smith) Ag. forma. Other freshwater algae listed were: *Oscillatoria formosa* Bory, *O. brevis* Kütz., *Oedogonium Cleveanum* Wittr. forma *exotica* Hirn., *Oe. Paulense* Nordst. et Hirn., and *Pithophora variabile* Schmidle (listed as a new species, but lacking a Latin description).